



TECHNICAL REPORT M10

US Army Corps
of Engineers
Northwestern Division

SEDIMENTATION AND NAVIGATION STUDY OF THE MISSOURI RIVER, COPELAND BEND MILES 569 TO 564.5

HYDRAULIC MICRO MODEL INVESTIGATION

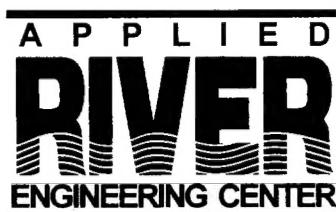
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13. ABSTRACT (Maximum 200 words) A sedimentation and navigation study of the Missouri River at Copeland Bend, between Miles 569 and 564.5, was conducted by the U.S. Army Corps of Engineers, Northwestern Division, Omaha, Nebraska. The study examined the effects of structural modifications to existing dikes upon the navigation channel and also upon lateral erosion. The study was conducted at the Applied River Engineering Center in St. Louis, Missouri. A physical hydraulic micro model was used to evaluate numerous dike modification plans to existing dikes located off the left descending bank of Copeland Bend. Results indicated that most of the proposed modifications to dikes, such as small notches, minimal elevation degradation, addition of chevrons, etc. had little or no negative effect to the integrity of the navigation channel. In addition, tests showed that major modifications made along the left descending bank, such as bankline excavation, could be tolerated as long as the existing dikes were left in place. Flow visualization showed that most tests generated new flowlines along or near the left descending bank, which would be considered an added environmental benefit.						
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Technical Report M10

**SEDIMENTATION STUDY OF THE MISSOURI RIVER,
COPELAND BEND
Miles 569 to 564.5**

HYDRAULIC MICRO MODEL INVESTIGATION

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INTRODUCTION

A sedimentation study of the Missouri River was initiated by the Northwestern Division of the U.S. Army Corps of Engineers. The study was carried out in order to evaluate a number of proposed design alternatives and/or modifications to existing channel navigation and bank stabilization structures in Copeland Bend, between River Miles 567.8 and Mile 565.3.

Personnel involved in the study and overseeing the project included: Mr. Al Swoboda and Mr. John LaRandeau, Northwestern Division, Mr. John Remus and Mr. Dan Pridal, Omaha District, Mr. Michael Bart, Ms. Christine Altendorf, and Ms. Marie Vanderpool, Kansas City District.

The study was conducted between the period November 1998 and March 1999 using a physical hydraulic micro model. The micro model was operated at the St. Louis District Applied River Engineering Center, St. Louis, Missouri. Personnel conducting model testing included Mr. Robert Davinroy, Mr. David Gordon, Mr. Aron Rhoads, Mr. Edward Riiff, and Mr. James Abbott, all of the St. Louis District.

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BACKGROUND

This report details the investigation of a sedimentation study of the Missouri River at Copeland Bend, River Miles 569 to 564.5. Micro Modeling was used to evaluate the sediment transport and lateral bankline erosion response trends that could be expected to occur in the river from various design alternatives and/or modifications.

Model testing alternatives were conceptualized and submitted by members of a study team representing the U.S. Army Corps of Engineers, Northwestern Division, Omaha, Kansas City and St. Louis Districts. The primary goal was to evaluate the impacts of these alternatives, if any, on the resultant bed configuration (sediment transport response) and lateral bankline erosion trends in Copeland Bend. Studying the effects of modifying existing dike structures for the improvement of the quantity and quality of aquatic habitat, while maintaining the integrity of the navigation channel, was the primary purpose of this study.

1. Problem Description

Plates 1, 2, and 3 are maps depicting the characteristics, configuration, and nomenclature of the Missouri River through this particular study reach. A combination of wooden pile and rock dike structures (Plate 2) have been constructed and maintained by the Omaha District to achieve a self maintaining navigation channel and stable channel alignment along the left descending bankline.

Between Miles 569 and 564.5, a total of 37 channel improvement structures exist on the river. The focus of this particular study was to examine the possibility of modifying structures located on the inside of Copeland Bend, between Miles 567.8 and 565.3, and examining the impacts of these modifications to the

condition of the adjacent navigation channel and to the stability of the left descending bankline.

In addition, changes or impacts to shallow water habitat on the inside of the bend were of a primary concern. It was highly desirable to create additional shallow water habitat and depth diversity throughout Copeland Bend for the generation of aquatic benefits within the overall river reach.

2. Field Investigation

In December of 1998, river engineers from the St. Louis District made a field investigation of the study reach. Plates 4 through 10 are photographs taken during this inspection. The following observations were noted:

- The downstream parabolic eddy formation generated from each of the dike structures along the inside of Copeland Bend was approximately as long as the spacing between dikes. Generally, it was estimated that the streamwise axis length of each eddy was approximately 3 times the effective length of each dike structure.
- The above observation indicated that the dikes, although not particularly long, were maximizing the available energy of the Missouri River. The dikes were effectively and efficiently protecting the left descending bankline on the inside of the riverbend.
- No excessive erosion was noted along the left descending bankline, indicating that a stable, average contraction width (bank to bank) of approximately 700 feet was being maintained by the dikes throughout Copeland Bend.

- All of the dikes were angled slightly downstream, which has caused small bankline roundouts to occur below each structure. The bankline roundouts appeared to be stable, however, and the integrity of the dikes was not in jeopardy.
- An unusual amount of mature trees were destroyed near and along the left descending bankline due to beaver impacts. This could cause future lateral erosion of the existing bankline.

MICRO MODEL DESCRIPTION

1. Scales and Bed Materials

Plate 11 is a photograph of the Copeland Bend hydraulic micro model used in this study. The scales were 1 inch = 300 feet, or 1:3600 horizontal, 1 inch = 20 feet, or 1:240 vertical, for a 15 to 1 distortion ratio. This distortion supplied the necessary forces required for the simulation of sediment transport conditions similar to those of the prototype. Both the bed material and the erodible floodplain section were composed of granular plastic urea, Type II, with a specific gravity of 1.23.

2. Appertures

The model was constructed according to 1996 aerial photographs of the Missouri River. Flow was controlled via an electronic/computer program interfaced with a centrifugal pump and a mechanical process control valve. Stages and dike structures were recorded with a mechanical three-dimensional digitizer. Bathymetry of the model bed was collected with a laser. Slope was controlled by rotational jacks located within the hydraulic flume. Dynamic flow and sediment transport equilibrium (model input and output) was maintained throughout all testing simulations.

MICRO MODEL TESTS

1. Calibration

The calibration of the micro model involved the adjustment of water discharge, sediment load, time scale, and slope. These parameters were adjusted until the measured bed response and the lateral bankline erosion trends of the model were similar to the prototype.

In this particular study, the banks and floodplain of the left descending bankline, between Miles 567.8 and 565.3, were comprised of the same material as the bed in order to study the impacts of future lateral erosion migration. All other bankline areas were fixed in the model. The modeling calibration approach was to establish a stable upper energy regime in the model in such a manner as to allow for both sufficient sediment transport in the navigation channel and reasonable erosion tendencies along the left descending bankline. An energy threshold was established in the model whereby a stable left descending "equilibrium" bankline was achieved during the base test.

Numerous repeated tests were conducted during the calibration of the model verifying that bankline equilibrium had been established. Field investigation indicated a stable left descending bankline in the prototype. Removal or compromise in the existing structures immediately initiated varying degrees of lateral erosion in the model.

A thin-walled metal template forming the prototype alignment configuration of the left descending bankline of the Missouri River, between Miles 567.8 and 565.3, was constructed based upon aerial photography. The elevation of the banks and floodplain landward of this template were molded with model sediment. After the template was removed, successive design hydrographs (Plate 12) were run until model stability was reached. The model was then surveyed, and a comparison

of the model bankline was made to the original bankline alignment of the template. Calibration variables were adjusted and the process was repeated until the bankline could be maintained in the model as close to the original prototype alignment (template alignment) as possible. Once this condition was achieved, the process was repeated several additional times to ensure replication. This stable model bankline was referenced on all plates as the “equilibrium line” and was delineated in blue for reference.

A. Design Hydrograph

The effective discharge run throughout this model study represented that hydrograph generating an average expected sediment response expected to occur in the prototype. Plate 12 shows the graph of this model hydrograph. Because of the constant variation experienced in the prototype, the effective discharge was used to theoretically analyze the average expected sediment response during any given year. During all testing, the design hydrograph was run successively until stability was observed in both the channel and along the left descending bankline.

It should be realized that because of the nature of the lightweight bed sediment materials that are typically used in movable bed models, hydrographs are not directly scaleable. Thus, in this particular study, although the peak stage of the hydrograph used for testing was at +5 CRP in the micro model, the energy of the model under this condition was representative of much higher flows experienced in the prototype. The design hydrograph then, in simplistic terms, represents an energy condition in the model that effectively enables the model to replicate realistic sediment response conditions similar those observed in the prototype.

B. Prototype Surveys

The 1996 and 1991 prototype surveys were used in this study to determine the general bed distribution characteristics that have existed in the prototype over recent years (Plates 13 and 14). All depths and color contours were referenced in feet above or below the Construction Reference Plane (CRP) established on the Missouri River.

The bathymetry indicated that the trends of the two surveys were very similar. Beginning at Mile 569.0, the channel thalweg was observed off the right descending bank, with depths between –15 and –20 CRP. Between Miles 568.6 and 568.2, thalweg depths decreased to between –10 and –15 CRP.

Between Mile 568.2 and 566.5, the thalweg was again located adjacent to the right descending bank, with depths between –15 and –20 CRP. Depths decreased near Mile 566.5 to between –10 and –15 CRP. Between Mile 566.5 and 565.3, the thalweg again developed against the right descending bank. Overall thalweg depths were between –15 and –20 CRP, with deeper thalweg depths of –20 and –30 CRP located between Mile 566.0 and 565.8. Within this segment, the navigation channel narrowed considerably, approximately 350 feet in width, as a result of the inside point bar formation between Mile 566.2 and 565.0.

The only crossing in the entire study reach was observed between Miles 565.3 and 565.0. Depths in the navigation channel were generally between –10 and –15 CRP. From Mile 565.0 to the end of the study reach, the thalweg developed against the left descending bank, with depths between –15 and –20 CRP.

There were slight deviations between the bed configurations of the two surveys worth noting. Dikes on the left descending bank along the study reach were generally more effective in generating localized scour in the 1991 survey as compared to the 1996 survey. In addition, the navigation channel was slightly

wider and shallower in the bend at Mile 566.0 and in the bend below Mile 565 in 1991 as compared to 1996.

2. Base Test

Plate 15 shows the resultant bed configuration of the micro model base test. The base test was developed from the simulation of successive design hydrographs until bed stability was reached and a similar bed response was achieved as compared with the prototype surveys. The observed trends of the model were as follows:

At Mile 569.0, the thalweg developed against the right descending bank. The thalweg remained against the right descending bank to Mile 566.7. Depths in the channel were predominately between –10 and –15 CRP, with the exception of two areas located at Miles 567.8 and 567.2. Depths in these areas were between –20 and –30 CRP.

Between Miles 566.7 and 566.2, the thalweg was not well defined, and depths decreased to –10 and –15 CRP.

Between Miles 566.2 and 565.4, the thalweg again developed adjacent to the right descending bank, with depth predominately at –15 to –20 CRP. Apex bend scour off the point bar at Mile 566.0 was between –20 and –30 CRP.

A crossing developed between Mile 565.4 and 565.0, with depths in the channel between –10 and –15 CRP. Below Mile 565.0, the thalweg developed off the left descending bank, with depths –15 to –30 CRP.

The general bathymetric trends of the base test were very similar to those of the two observed prototype surveys of 1991 and 1996. Generally, the thalweg was located in the same positions as in the prototype. The depositional patterns

along the left descending bank were also similar to the prototype, including the formation of the dominant point bar at Mile 566.0.

As described previously, the model allowed for lateral erosion between Miles 567.8 and 565.3. A model bankline equilibrium line was established during calibration (blue line, Plate 15). This line was approximately 0 to 300 feet to the left of the existing prototype bankline alignment (red line, Plate 15). This blue equilibrium line served as a comparison for all design alternative tests.

Plate 16 shows the flow visualization of the base test. All flow visualization photographs were captured throughout the model tests with the stage of the model at approximately + 2 CRP. Results indicated that the flow through the study reach was distributed fairly uniformly in the navigation channel, between the ends of the dikes and the right descending bankline, except at Mile 566.0, where flow was more concentrated at the apex of the bend adjacent to the point bar. The influence of the dikes in diverting flow away from the left descending bank and generating eddies was observed in the model. Flow visualization did not capture the eddies, however, the visualization did show the relative slower moving water within the dike field.

3. Design Alternative Tests

A number of design alternatives were tested in this study. The effectiveness of each plan was evaluated by comparing the resultant bed bathymetry of the plan test to the resultant bed bathymetry of the base test. A difference map was also generated for each alternative as compared to the base test. This map was generated mainly for assistance in visualizing changes that occurred within channel border areas along the left descending bank throughout the erodible section of the model. Sediment transport observed along this region was less dynamic than the main channel.

Less reliance on the difference maps were used in determining design alternative changes experienced in the main channel. Observed sediment transport in the main channel was very dynamic, which introduced a fair amount of natural "noise" similar to what could also be expected to occur in the prototype.

Alternative 1. Degrade All Existing Dikes To -2 CRP. Alternative 1 involved the degradation of all dikes to -2 CRP on the left descending bank, between Miles 567.8 and 565.3. Results (Plates 17, 18, 19) indicated the following trends:

Depths and widths in the navigation channel remained generally the same as in the base test. The left descending bankline moved landward from the base test equilibrium line approximately 200 feet on the average. Depths in this area increased between 0 and 15 feet, with the average depth increase between 2 and 5 feet.

Flow visualization showed that flow distribution through the main channel was similar to the base test. Flow still had a tendency to be concentrated at the apex of the bend at Mile 566.0. A greater amount of flow was observed within the dike fields as compared to the base test.

Alternative 2. Degrade All Dikes To -2 CRP and Add 16 New Chevrons At +2 CRP. Alternative 2 involved the degradation of all dikes to -2 CRP as in Alternative 1 and the addition of 16 new chevrons. The chevron crown elevations were placed in the model at +2 CRP. The chevrons were of the blunt-nosed type. Each deflection leg was 75 feet in length at a centerline deflection angle of 30 degrees. Radius of the blunt nose was approximately 25 feet. The chevrons were strategically placed in the middle of each dike spacing, except between dikes 612.0 and 611.85, where the structures were placed closer to the existing dikes. The chevrons were streamlined just within the dike endpoints for the purposes of generating maximum effects to the navigation channel. The goal was to place the structures as close to the main channel as possible but still

within the influence of the dike fields. Results (Plates 20, 21, 22) indicated the following trends:

Depths and widths in the navigation channel remained generally the same as in the base test. The left descending bankline moved slightly landward from the base test equilibrium line, between a few feet and approximately 150 feet.

Depths increased in these areas approximately 0 to 5 feet. Between Mile 565.9 and 565.7, the bankline moved riverward approximately 100 feet.

Flow visualization showed that flow distribution through the main channel was similar to the base test. Flow still had a tendency to be concentrated at the apex of the bend at Mile 566.0. A greater amount of flow was distributed over the dike fields as compared to the base test. A fair amount of flow developed along the left descending bankline as compared to the base test, between Miles 567.0 and 566.5. Visual observation indicated that some of the chevrons produced flow "shadows" directly downstream of each structure as a result of individual boundary effects.

Alternative 3. Degrade Alternating Dikes To -2 CRP. Alternative 3 involved the degradation of alternating dikes along the left descending bank. Results (Plates 23, 24, 25) indicated the following trends:

Depths and widths in the navigation channel remained generally the same as in the base test. Some additional shoaling was experienced in the navigation channel crossing between Mile 565.5 and 564.8.

The bankline moved slightly landward along the left descending bank as compared to the base test equilibrium line, between 0 and approximately 150 feet on the average. Depths increased between 0 and 5 feet. Between Mile 565.9 and 565.7, the bankline moved riverward approximately 100 feet.

Flow visualization showed that flow distribution through the main channel was similar to the base test. Flow still had a tendency to be concentrated at the apex of the bend at Mile 566.0. A greater amount of flow was distributed over the dike fields as compared to the base test.

Alternative 4. Degrade Alternating Dikes To -2 CRP And Add 16 New

Chevrons At +2 CRP. Alternative 4 involved the degradation of alternating dikes to -2 CRP along the left descending bank in addition to 16 New Chevrons placed in the same configuration as Alternative 2. Results (Plates 26, 27, and 28) indicated the following trends:

Depths and widths in the navigation channel remained generally the same as in the base test. The left descending bankline laterally eroded landward from the base test equilibrium line approximately 200 feet on the average. Depths near the equilibrium line increased between 0 and 15 feet.

Flow visualization showed that flow distribution through the main channel was similar to the base test. Flow still had a tendency to be concentrated at the apex of the bend at Mile 566.0. Results also indicated that more flow was distributed over the dike fields as compared to the base test. In addition, some of the chevrons produced flow "shadows" directly downstream of each structure as a result of individual boundary effects, similar to what was observed in the previous Alternative 2.

Alternative 5. All Dikes Notched To -5 CRP. Alternative 5 involved excavating a 50-ft landward notch of all existing dikes between Miles 567.8 and 565.3. Results (Plates 29, 30, and 31) indicated the following trends:

Depths and widths in the navigation channel remained generally the same as in the base test. The left descending bankline eroded landward from the base test

equilibrium line approximately 150 to 200 feet on the average. Depths near the equilibrium line increased between 5 and 15 feet.

Flow visualization showed that flow distribution through the main channel was similar to the base test. Flow still had a tendency to be concentrated at the apex of the bend at Mile 566.0. Results also indicated a continuous path of developed, concentrated flow passing through most of the notched areas, along the left descending bankline. A sinuous flow pattern was also observed within the notched areas, between Miles 567.5 and 566.5.

Alternative 6. All Dikes Notched To -5 CRP and Add 16 New Chevrons At +2 CRP. Alternative 6 involved excavating a 50-ft landward notch on all existing dikes between Miles 567.8 and 565.3 in addition to 16 new chevrons strategically placed between the dikes as in Alternative 2. Results (Plates 32, 33, 34) indicated the following trends:

Depths and widths in the navigation channel were generally the same as in the base test. The left descending bankline eroded approximately 100 feet on the average, landward from the base test equilibrium line. Increased depths along this area were between 2 and 15 feet.

Flow visualization showed that flow distribution through the main channel was similar to the base test. Flow still had a tendency to be concentrated at the apex of the bend at Mile 566.0. Results indicated that a definite, secondary flow pattern was developed through the notches along the left descending bank. The flow pattern was roughly the width of the notches and contained a fair amount of sinuosity throughout the dike field. Observations also indicated that some of the chevrons produced flow "shadows" directly downstream of each structure as a result of individual boundary effects, similar to what was observed in the previous chevron alternatives.

Alternative 7. Degrade All Dikes To -2 CRP, Add 16 New Chevrons At +2 CRP, Add 6 New Bendway Weirs At -15 CRP.

Alternative 7 was a repeat of Alternative 2 with the addition of 6 Bendway Weirs placed in the navigation channel between Miles 566.2 and 565.8. Results (Plates 35, 36, 37) indicated the following trends:

Depths and widths in the navigation channel remained similar to the base test, except between Miles 566.2 and 565.0. In this stretch several changes occurred. Depths decreased within the Bendway Weir field approximately 15 feet as compared to the base test. The channel did not significantly widen adjacent to the weir field. Downstream of the weir field, the navigation channel narrowed between Miles 565.3 and 565.0.

The left descending bankline eroded slightly landward from the base test equilibrium line, between 0 and 150 feet on the average. Depths increased between 0 and 15 feet along this area. Between Miles 566.0 to 565.6, the bankline moved riverward approximately 200 feet.

Flow visualization indicated that changes in flow near the Bendway Weir field were not significantly different than what was observed in the base test. Observations also indicated that some of the chevrons produced flow "shadows" directly downstream of each structure as a result of individual boundary effects, similar to what was observed in the previous chevron alternatives.

Alternative 8. Bankline Degradation Test With Existing Dikes In Place.

Alternative 8 involved degrading the left descending bankline between 0 and 400 feet, or approximately 300 feet on the average landward from the base test equilibrium line, to a depth of approximately -10 CRP. Results (Plates 38, 39, 40) indicated the following:

Depths and widths in the navigation channel remained similar to the base test. Some slight deposition was observed in the channel between 566.6 and 566.7. Since the bankline was artificially degraded, no additional lateral erosion was observed.

Flow visualization indicated a greater amount of flow distributed over the dike field as compared to the base test. A continuous path of flow was observed along the excavated portion of the left descending bank.

Alternative 9. Existing Dikes Removed And Bankline Established Near

Equilibrium. Alternative 9 involved removing the existing dikes on the left descending bank between Miles 567.8 and 565.3. This test was performed to study the effects of dike removal directly on the navigation channel, assuming that the bankline and contraction width would be maintained. Results (Plates 41, 42) indicated the following trends:

There was a trend for additional shoaling in the navigation channel from approximately Miles 567 to 565.5, but depths through this area still remained below project depths. However, at the downstream crossing, between Mile 565.2 and 564.9, shoaling in the channel was above project depths. In this particular test, it was hoped that the effects of dike removal could be directly studied while maintaining the bankline equilibrium line of the base test. However, it was evident that this condition could not be totally achieved because the bankline immediately started to move landward from the base test equilibrium line during repeated testing, especially along the lower half of the point bar, between Miles 566.7 and 565.3. This test clearly showed that the removal of the dikes immediately effected the stability of the bankline and the integrity of the navigation channel. Flow visualization was not conducted during this test.

Alternative 10. Existing Dikes Removed And Bankline Degraded.

Alternative 10 involved removing all existing dikes and degrading the left descending bankline approximately 300 feet landward from the equilibrium line, to a depth of – 10 CRP. Results (Plates 43, 44, 45) indicated the following:

There was a tendency for minor shoaling to occur between Miles 567.4 and 567.2 similar to what was observed in Alternative 9. Between Miles 567.0 and 566.0, a loss of width and depth was experienced in the navigation channel. At Mile 565.1, a considerable amount of scour was experienced, indicating direct attack on the fixed bank portion of this reach of the model.

The left descending bankline eroded considerably landward from the excavated 300 foot alignment. The lower one half of the point bar, between Miles 556.3 and 565.5, receded on the average approximately 400 feet landward of the equilibrium line. The upper one half of the point bar, between Miles 567.4 to Miles 566.3, receded approximately 300 to 400 feet landward from the equilibrium line.

Flow visualization indicated a greater amount of flow distributed over the point bar as compared to the base test. A continuous path of flow was also observed along the excavated portion of the left descending bank.

RESULTS AND CONCLUSIONS

1. Summary of Model Tests

- Alternatives 1 through 6, which incorporated changes to the existing structures and/or additions of chevron structures, produced no major negative effects to the general depth and width trends of the navigation channel. These alternatives, to a varying degree, all showed a tendency for increased lateral erosion of the left descending bankline. However, in all cases, the lateral erosion reached a state of equilibrium in the model, whereas no further movement of the bankline was noted. Long term meandering tendencies along the inside of the bend or redirection of the channel thalweg as a result of these measures were not observed during these tests.
- Alternative 6 seemed to provide the greatest amount of diversity and environmental benefits as compared to all other alternatives. Flow visualization showed increased flow sinuosity through the notched areas, increased flow distribution over the dike fields, and positive boundary effects from both the dikes and the chevrons. Depths and widths in the navigation channel were still maintained.
- Alternative 7 showed that although the Bendway Weirs incurred some deposition within the weir field, the structures did not generate any major increase in adjacent navigation channel width.
- Alternative 8 showed that a relatively large amount of bankline degradation and increased depth distribution could be permitted on the inside of Copeland Bend as long as the existing dikes were not removed. Alternative 9 showed that the removal of all dikes threatened the integrity of the navigation channel.

- Flow visualization showed that the critical area where structural modifications had the most significant effect was between Miles 566.8 and Miles 566. Within this area, flow had a general tendency to widen out, probably due the combination of both the modifications and the loss of momentum through the channel.
- Alternative 10 showed that a contraction line width expansion of approximately 25 to 40 percent, incurred by the removal of all existing dikes as well as excavation of the existing bankline, would compromise the integrity of the navigation channel between Miles 567.0 and 566.0. This alternative was considered an extreme measure and was tested in order to gain a better understanding of how much change in contraction width could be tolerated without adversely effecting the navigation channel.
- Alternatives 8, 9 and 10 demonstrated that if extreme measures along the inside of Copeland Bend were incorporated (major excavation of the bankline or allowing substantial natural lateral erosion to occur), then the existing dike structures should be maintained to allow adequate conveyance of flow in the main channel.
- The model tests indicated that adequate navigation channel dimensions could be maintained in the model for alternatives 1,2,3,4,5,6, and 8. Visual observation of the model during these tests indicated that stable channel conditions as a result of the fixed contraction widths upstream and downstream of Copeland Bend played a large part in the positive sediment transport response achieved through the bend. The dike modification reach (approximately 2.5 miles) was relatively short. All proposed dike modifications occurred on the inside of the bend where energy was much lower. In addition, these measures still maintained most of the physical attributes of the existing dikes, with relatively minor structural modifications.

2. Interpretation of Model Test Results

In the interpretation and evaluation of the results of the tests conducted, it should be remembered that the results of these model tests were qualitative in nature.

Any hydraulic model, whether physical or numerical, is subject to biases introduced as a result of the inherent complexities that exist in the prototype.

Anomalies in actual hydrographic events, such as prolonged periods of high or low flows, are not reflected in these results, nor are any complex physical phenomena, such as the existence of underlying rock formations or other non-erodible variables.

This particular study effort also examined general erosion trends, a complex physical phenomena which lends to a large amount of assumptions. Without conducting extensive floodplain borings, it is extremely difficult to accurately predict future erosion rates or planform development. A homogenous material was used in the micro model for this analysis, while the prototype no doubt contains a varying degree of soil types, rock, and vegetative root wads. The intent of using the model in this regard was to examine contraction width change effects upon the overall sediment transport efficiency response in the navigation channel.

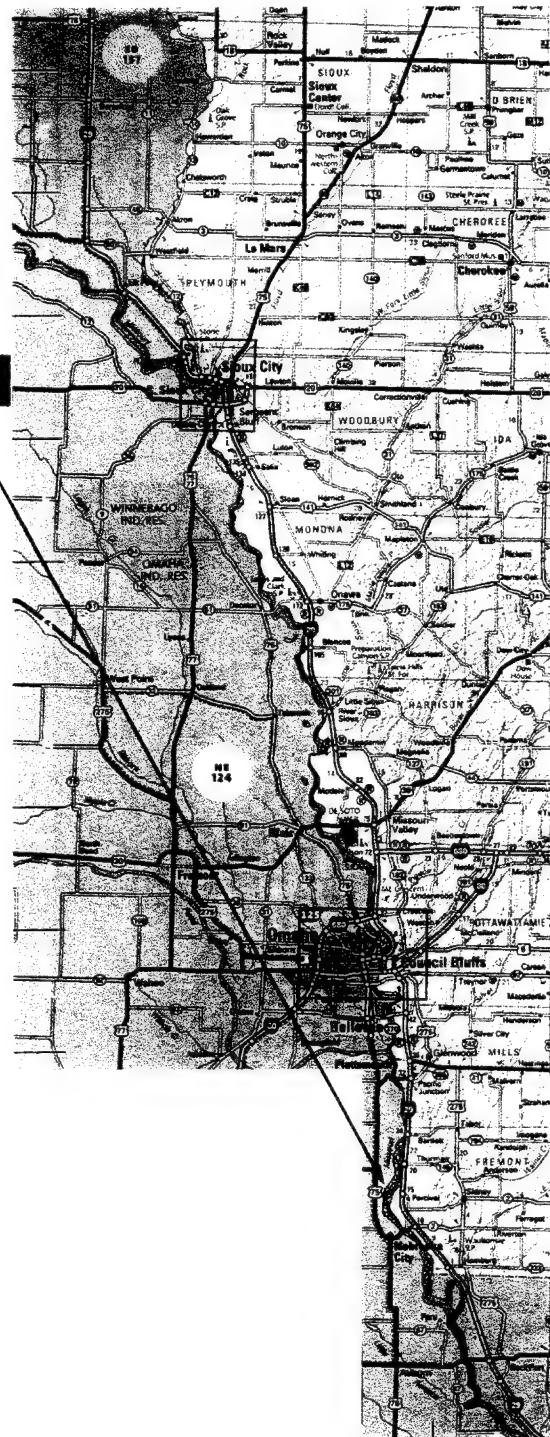
The model study was intended to serve as a tool to the engineer to guide in accessing the general trends that could be expected to occur in the actual river from a variety of imposed alternatives. Measures for final design may be modified based upon special requirements, real estate and construction considerations, environmental impacts, engineering knowledge, etc.

APPENDIX

The following is a list of all plates to follow in numbered order:

- Plate 1. Vicinity Map of Micro Model Study Reach
- Plate 2. Study Reach Map
- Plate 3. Study Reach Map
- Plate 4. Field Photos of Dec. 21, 1998
- Plate 5. Field Photos of Dec. 21, 1998
- Plate 6. Field Photos of Dec. 21, 1998
- Plate 7. Field Photos of Dec. 21, 1998
- Plate 8. Field Photos of Dec. 21, 1998
- Plate 9. Field Photos of Dec. 21, 1998
- Plate 10. Field Photos of Dec. 21, 1998
- Plate 11. Photograph of Copeland Bend Micro Model
- Plate 12. Model Design Hydrograph
- Plate 13. 1991 Prototype Survey
- Plate 14. 1996 Prototype Survey
- Plate 15. Base Test
- Plate 16. Flow Visualization, Base Test
- Plate 17. Alternative 1
- Plate 18. Alternative 1 Difference Map
- Plate 19. Flow Visualization, Alternative 1
- Plate 20. Alternative 2
- Plate 21. Alternative 2 Difference Map
- Plate 22. Flow Visualization, Alternative 2
- Plate 23. Alternative 3
- Plate 24. Alternative 3 Difference Map
- Plate 25. Flow Visualization, Alternative 3
- Plate 26. Alternative 4
- Plate 27. Alternative 4 Difference Map
- Plate 28. Flow Visualization, Alternative 4

- Plate 29. Alternative 5
- Plate 30. Alternative 5 Difference Map
- Plate 31. Flow Visualization, Alternative 5
- Plate 32. Alternative 6
- Plate 33. Alternative 6 Difference Map
- Plate 34. Flow Visualization, Alternative 6
- Plate 35. Alternative 7
- Plate 36. Alternative 7 Difference Map
- Plate 37. Flow Visualization, Alternative 7
- Plate 38. Alternative 8
- Plate 39. Alternative 8 Difference Map
- Plate 40. Flow Visualization, Alternative 8
- Plate 41. Alternative 9
- Plate 42. Alternative 9 Difference Maps
- Plate 43. Alternative 10
- Plate 45. Alternative 10 Difference Maps
- Plate 46. Flow Visualization, Alternative 10



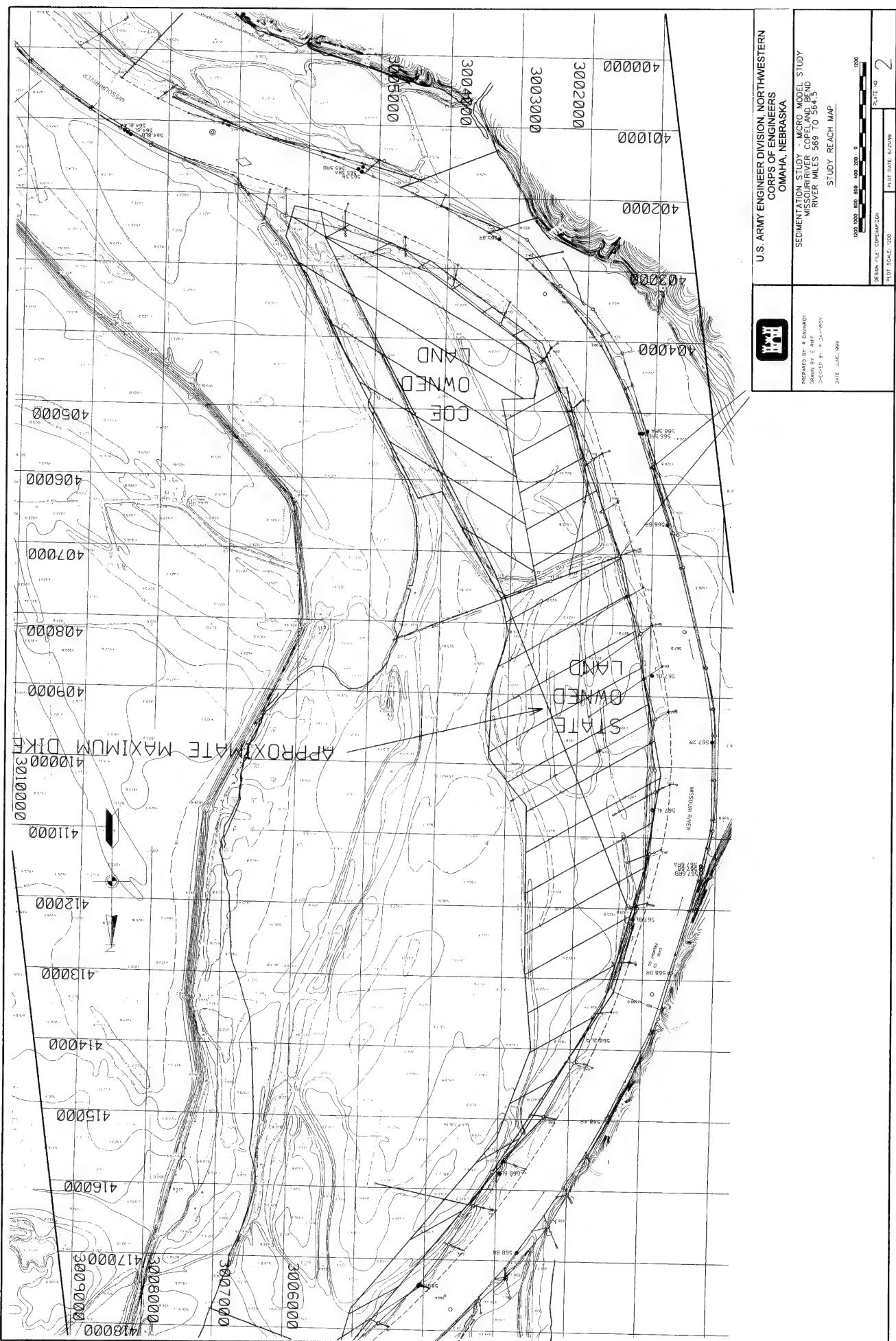
U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PREPARED BY: A. Rhoads
CHECKED BY: R. Devincenzi

DATE: JULY, 1999

SEDIMENTATION STUDY – MICRO MODEL STUDY
MISSOURI RIVER COPELAND BEND
RIVER MILES 569 TO 564.5
VICINITY MAP OF MICRO MODEL STUDY REACH

PLATE NO. 1





	U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA
PREPARED BY: R. DAVIDSON DRAWN BY: A. SPEDDING CHECKED BY: J. SAWYER DATE: JUL 1, 1999	SEDIMENTATION STUDY - MICRO MODEL STUDY MISSOURI RIVER, COPELAND BEND RIVER MILES 569 TO 564.5 STUDY REACH MAP
	
SECTION LINE AND DRAFTER	PLATE NO. 2
PILOT SCALE: 1:2000	PILOT DATE: 7/10/99





**Copeland Bend, Looking Across the Floodplain Toward
the Left Descending Bank, From Nebraska Bluff**

	U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA
PREPARED BY: R. Davinroy CHECKED BY: D. Gordon DATE: FEBRUARY, 1998	Sedimentation Study Missouri River, Copeland Bend Field Photos of Dec. 21, 1998
Field Conditions: Temp 5° Wind-chill -30° Flurries	PLATE NO. 4



Copeland Bend, Looking Upstream at Dike 612.5

	<p>U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA</p>
<p>PREPARED BY: R. Davinroy CHECKED BY: D. Gordon DATE: FEBRUARY, 1998</p>	<p>Sedimentation Study Missouri River, Copeland Bend Field Photos of Dec. 21, 1998</p>
<p>Field Conditions: Temp 5° Wind-chill -30° Flurries</p>	
<p>PLATE NO. 5</p>	



Copeland Bend, Looking Downstream At Dike 612.5

		U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA	
PREPARED BY: R. Davinroy CHECKED BY: D. Gordon DATE: FEBRUARY, 1998		Sedimentation Study Missouri River, Copeland Bend Field Photos of Dec. 21, 1998	
Field Conditions: Temp 5° Wind-chill -30° Flurries			PLATE NO. 6



Copeland Bend, Looking Downstream From Dike 612.5

	U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA
PREPARED BY: R. Davinroy CHECKED BY: D. Gordon DATE: FEBRUARY, 1998	Sedimentation Study Missouri River, Copeland Bend Field Photos of Dec. 21, 1998
Field Conditions: Temp 5° Wind-chill -30° Flurries	PLATE NO. 7



Copeland Bend, Looking Upstream at Dike 612.6

		U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA
PREPARED BY: R. Davinroy CHECKED BY: D. Gordon DATE: FEBRUARY, 1999	Sedimentation Study Missouri River, Copeland Bend Field Photos of Dec. 21, 1998	
Field Conditions: Temp 5° Wind-chill -30° Flurries		PLATE NO. 8



Copeland Bend, Looking Directly at Dike 612.6

	U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA
PREPARED BY: R. Davinroy CHECKED BY: D. Gordon DATE: FEBRUARY, 1998	Sedimentation Study Missouri River, Copeland Bend Field Photos of Dec. 21, 1998
Field Conditions: Temp 5° Wind-chill -30° Flurries	
PLATE NO. 9	

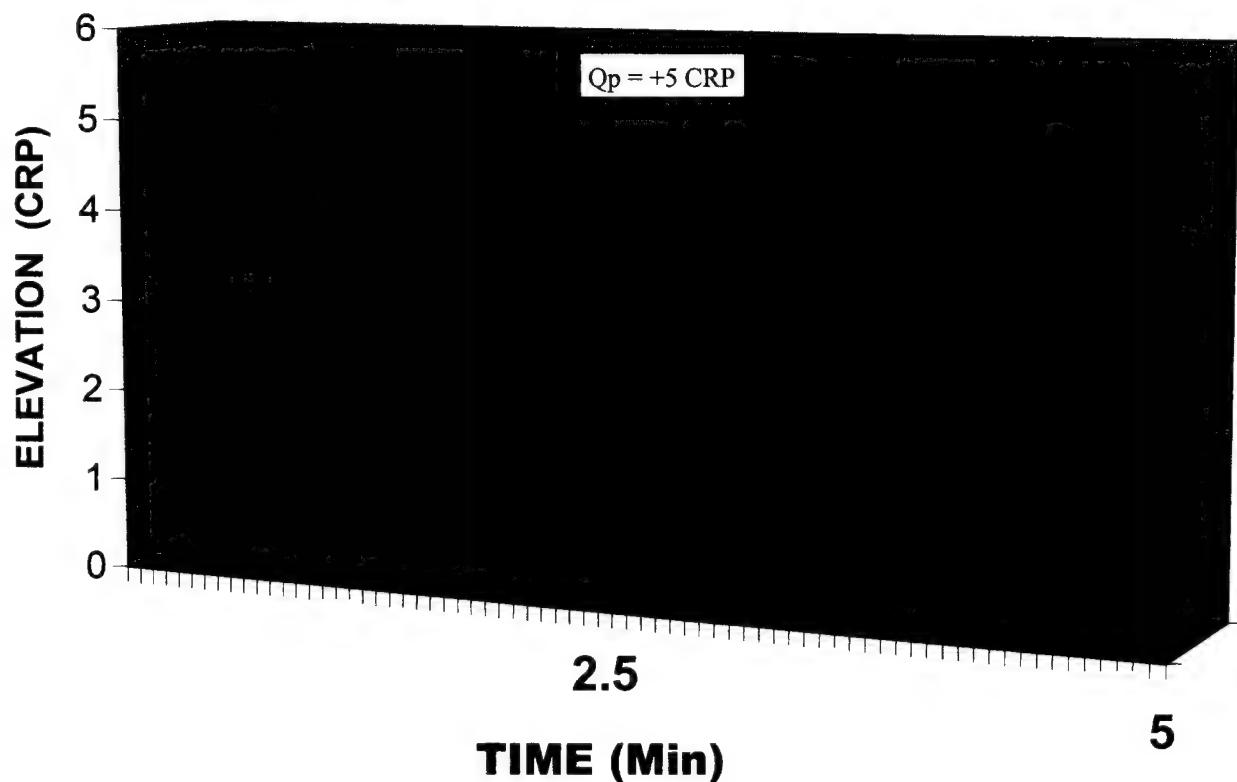


Copeland Bend, Looking Upstream at Dike 612.7

		U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA
PREPARED BY: R. Davinroy CHECKED BY: D. Gordon DATE: FEBRUARY, 1998	Sedimentation Study Missouri River, Copeland Bend Field Photos of Dec. 21, 1998	
Field Conditions: Temp 5° Wind-chill -30° Flurries		PLATE NO. 10



U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA	
SEDIMENTATION STUDY - MICRO MODEL STUDY MISSOURI RIVER COPELAND BEND RIVER MILES 569 TO 564.5	
PHOTOGRAPH OF COPELAND BEND, MICRO MODEL	
PREPARED BY: R. DAVENPORT DRAWN BY: E. REFF CHECKED BY: R. DAVENPORT DATE: JUNE 1969	DESIGN FILE: COPEBEND.DJC PLOT DATE: 6/21/99 PLOT FILE: COPEBEND.DJC PLOT NO: 11



	U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA
PREPARED BY: R. Davinroy CHECKED BY: D. Gordon DATE: FEBRUARY, 1999	Sedimentation Study Missouri River, Copeland Bend Model Design Hydrograph
	PLATE NO. 12

ELEVATIONS REFERENCED
TO CRP

ELL. 5
ELL. 0
ELL. 5
ELL. 10
ELL. 15
ELL. 20
ELL. 30

IOWA
FREMONT COUNTY

70 100 200

NEBRASKA
OTOE COUNTY

	U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA	
PREFACED BY: 2. DRAWN BY: 3. CHECKED BY: 4. APPROVED BY: DATE: APR 1999		SEDIMENTATION STUDY - MICRO MODEL STUDY MISSOURI RIVER COPEL AND BEND RIVER MILES 569 TO 564.5 1991 PROTOTYPE SURVEY
DESIGN FILE NUMBER: 13		DATE NO. 13
1000 800 600 400 200 0	1000	1000 800 600 400 200 0
POST SCALE 1:62500	POST DATE 4/17/99	PLAT DATE 4/17/99

ELEVATIONS REFERENCED
TO CRP

TO CRP

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ELL. 0
ELL. -5
ELL. -10
ELL. -15
ELL. -20
ELL. -25

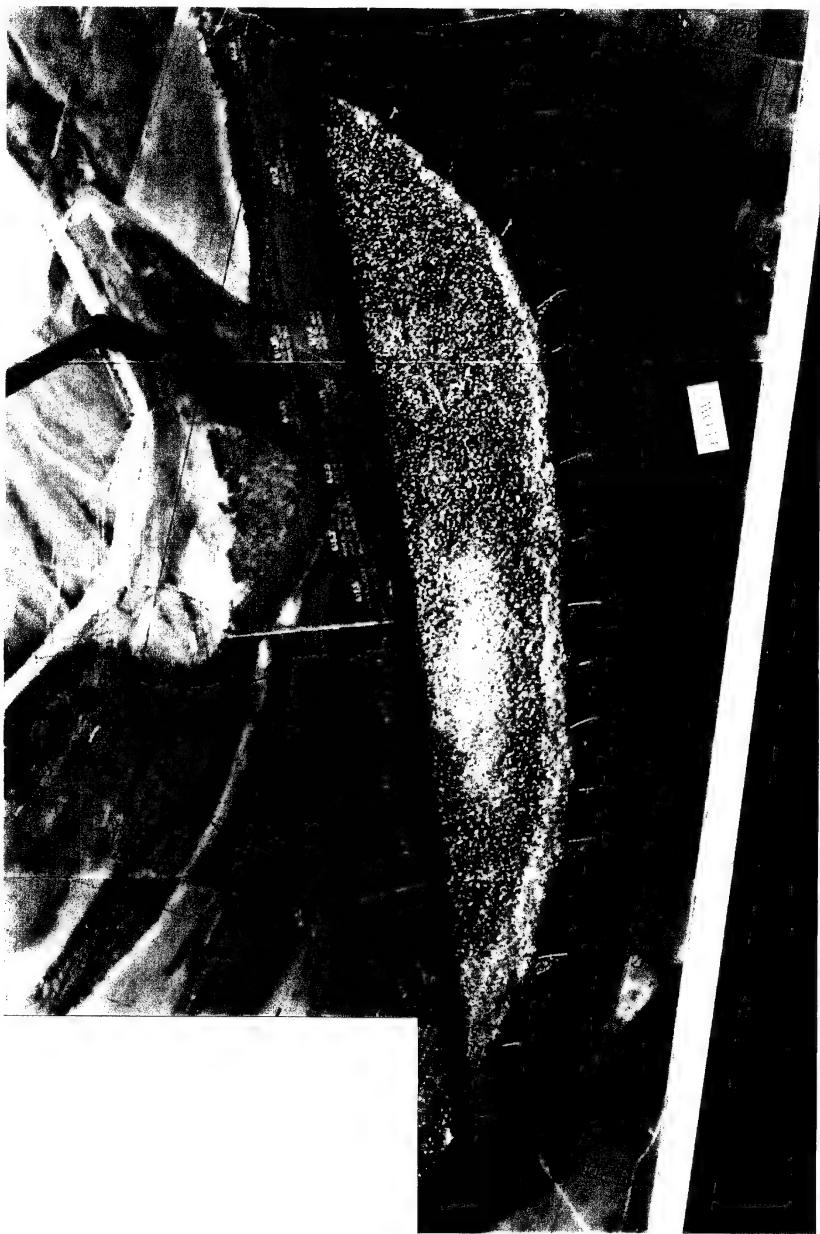
IOWA
FREMONT COUNTY

BLUE LINE • EQUILIBRIUM
LINE, MICRO MODEL

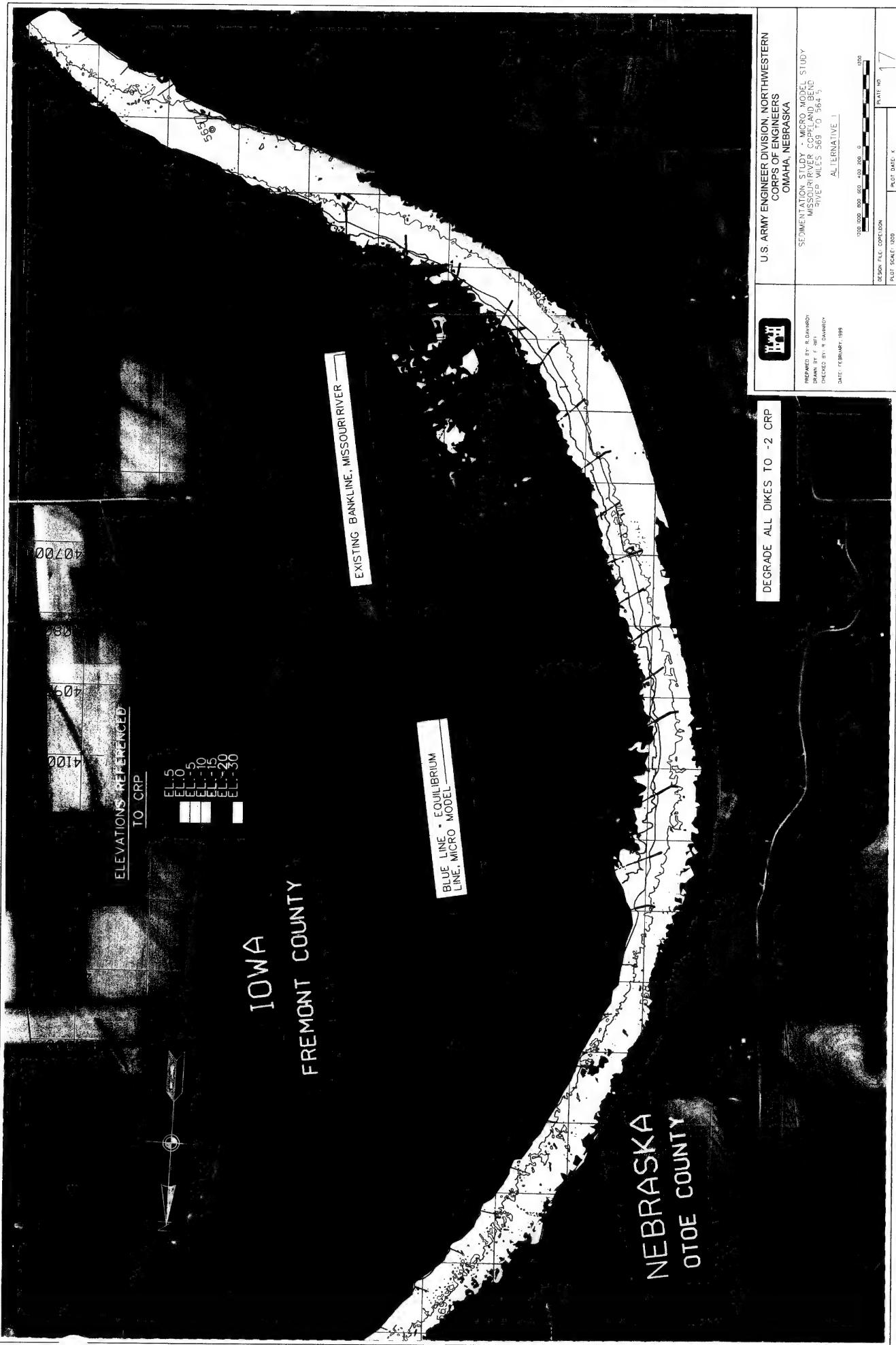
EXISTING BANKLINE, MISSOURI RIVER

NEBRASKA
OTOE COUNTY

 U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA	SEDIMENTATION - MICRO MODEL STUDY MISSOURI RIVER COPLAND BEACH RIVER MILES 569 TO 564.5 BASE TEST	15
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	U. S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA
PREPARED BY: R. Denevry CHECKED BY: G. Gossela	Sedimentation Study Missouri River, Copeland Bend Flow Visualization Base Test
DATE: 6-20-94 TIME: 1500	PLATE NO. 16



IOWA
FREMONT COUNTY

15 52 25 15 20

BLUE LINE - EQUILIBRIUM
LINE, MICRO MODEL

EXISTING BANKLINE, MISSOURI RIVER -

NEBRASKA OIGE COUNTY

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS
OMAHA, NEBRASKA

SEDIMENTATION STUDY - MICRO MODEL STUDY
MISSOURI RIVER COPELAND BEEND
RIVER MILES 569 TO 564.5

ALTERNATIVE 1 DIFFERENCE MAP



	U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA
PREPARED BY: A. RICHARDS CHECKED BY: R. DAVIDSON 16 APR 1999	Sedimentation Study, Missouri River Copeland Bend, Flow Visualization Alternative 1
9 1000	Degrade All Dikes to -2 CRP
	DATE NO 19

ELEVATIONS REFERENCED

TO CRP

EL-5
EL-0
EL-5
EL-10
EL-15
EL-20
EL-25
EL-30

IOWA
FREMONT COUNTY

EXISTING BANKLINE, MISSOURI RIVER

BLUE LINE - EQUILIBRIUM
LINE, MICRO MODEL

NEBRASKA
OTOE COUNTY

DEGRADE ALL DIKES TO -2 CRP,
AND ADD 16 - NEW CHEVRONS
AT +2 CRP

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS
OMAHA, NEBRASKA
SEDIMENTATION STUDY - MICRO MODEL STUDY
MISSOURI RIVER, COPELAND AND BEND
RIVER MILES 569 TO 564.5

DATE NO. 20
AL-PRIVAT VOL 1
1000 900 800 700 600 500 400 300 200 100
PLOT FILE: C:\PLOT\2004
PLOT SCALE: 1:2000
PLOT DATE: 6/21/99



	U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA
INVESTIGATOR: R. Dever CHECKED BY: D. Gordon DATE: 10-18-93	Sedimentation Study, Missouri River Copeland Bend, Flow Visualization 0 1000 Degrade All Dikes to 2-CRP, Chevrons at 2-CRP
	PLATE NO. 22 Alternative 2

ELEVATIONS REFERENCED

TO CRP

EL 5
EL 0
EL -5
EL -10
EL -15
EL -20
EL -30

IOWA

FREMONT COUNTY

NEBRASKA

OTOE COUNTY

BLUE LINE - EQUILIBRIUM
LINE, MICRO MODEL

EXISTING BANKLINE, MISSOURI RIVER

NEBRASKA
OTOE COUNTY

DEGRADE ALTERNATING DIKES TO -2 CRP

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA	
SEDIMENTATION STUDY - MICRO MODEL STUDY MISSOURI RIVER COFFLAND BEACH RIVER MILES 509.0 - 564.5	
ALTERNATIVE 1	
PREPARED BY: R. DAWBER DRAWN BY: C. HUFF CHECKED BY: J. DAWBER DATE: FEBRUARY 1999	SCALE: 1:20000 1000 800 600 400 200 0 200 1000 800 600 400 200 0 200 1000 800 600 400 200 0 200 1000 800 600 400 200 0 200
DESIGN ALL. COPIED PILOT SCALE: 1:2000	PILOT DATE: X
PILOT SCALE: 1:2000	PILOT DATE: 2/3

IOWA
FREMONT COUNTY

NEBRASKA
OTOE COUNTY

EXISTING BANKLINE, MISSOURI RIVER

BLUE LINE - EQUILIBRIUM
LINE, MICRO MODEL

15
10
5
0
5
10
15

U.S. ARMY ENGINEER DIVISION NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA	
MICRO MODEL STUDY SEDIMENTATION STUDY CO-FLAND BEACH RIVER MILES 509 TO 564.5	
ALTERNATIVE 3 DIFFERENCE MAP	
PREPARED BY: R. DAUBER DRAWN BY: T. REIF CHECKED BY: R. DAUBER DATE: JUNE 1998	PLATE NO. 24 10000 5000 4000 3000 2000 1000
DESIGN FILE OF 1:2000 PLOT SCALE 1:1200	PLOT DATE: 6/21/98



	U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA
PREPARED BY: R. Divers CHECKED BY: O. Green DATE: February 1991	Sedimentation Study, Missouri River Copeland Bend, Flow Visualization Alternative 3 Degrade Alternating Dikes to -2' G.P. PART NO: 25

ELEVATIONS REFERENCED

TO CRP

EL. 5
EL. 10
EL. 15
EL. 20
EL. 30

IOWA

FREMONT COUNTY

BLUE LINE = EQUILIBRIUM
LINE, MICRO MODEL

EXISTING BANKLINE, MISSOURI RIVER

NEBRASKA
OTOE COUNTY

DEGRADE ALTERNATING DIKES TO -2 CRP,
AND ADD 16 - NEW CHEVRONS @ -2 CRP

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS
OMAHA, NEBRASKA

SEDIMENTATION STUDY - MICRO MODEL
MISSOURI RIVER, CO-OP CLASS BE-1
RIVER MILES 569 TO 584.5

ALTERNATIVE 4

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PLOT SCALE: 1:200
PLOT FILE: COR4.DGN
PLOT DATE: X
PLATE NO: 26

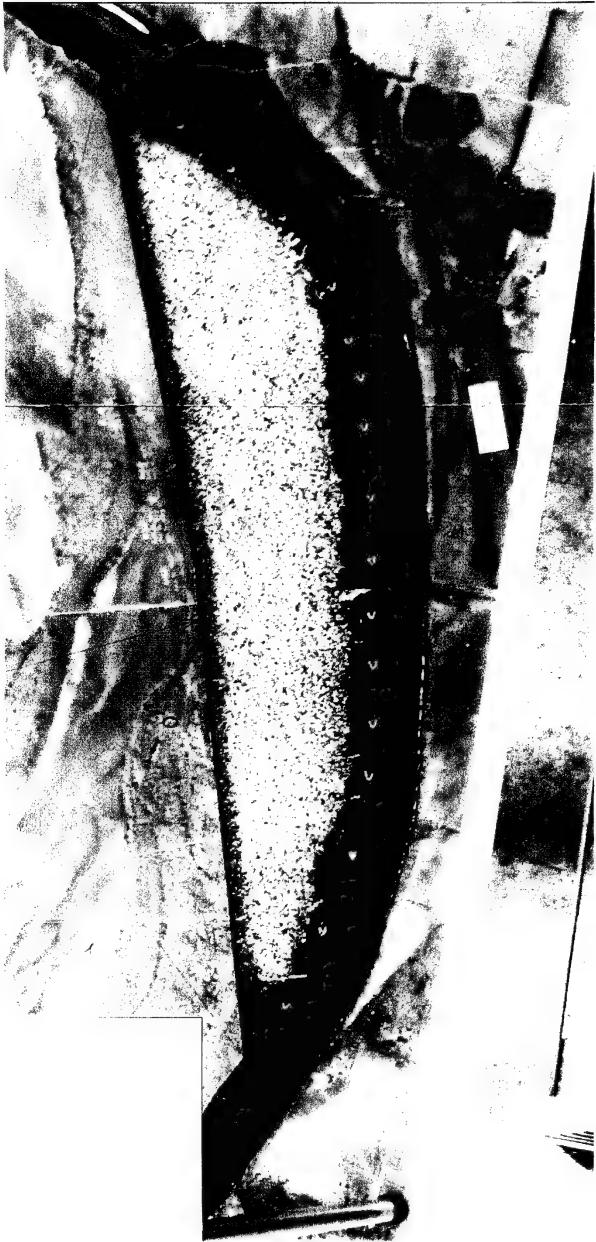
IOWA
FREMONT COUNTY

NEBRASKA
Otoe County

**BLUE LINE "EQUILIBRIUM
LINE, MICRO MODEL**

EXISTING BANKLINE, MISSOURI RIVER

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Trinity Lutheran Church



	U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA
PREPARED BY: R. Garrow CHECKED BY: C. Garrow DATE: FEBRUARY 1969	Sedimentation Study, Missouri River Copeland Bend, Flow Visualization 0 1000 Degrad Alternating Dikes to -2 CRP, Chevrons at -2 CRP Alternative 4 PLATE NO. 28

ELEVATIONS REFERENCED

TO CRP

EL. 5
EL. 0
EL. -5
EL. -10
EL. -15
EL. -20
EL. -30

IOWA

FREMONT COUNTY

EXISTING BANKLINE, MISSOURI RIVER

BLUE LINE = EQUILIBRIUM
LINE, MICRO MODEL

NEBRASKA
OTOE COUNTY

50' LANDWARD DIKE NOTCHED @ -5 CRP

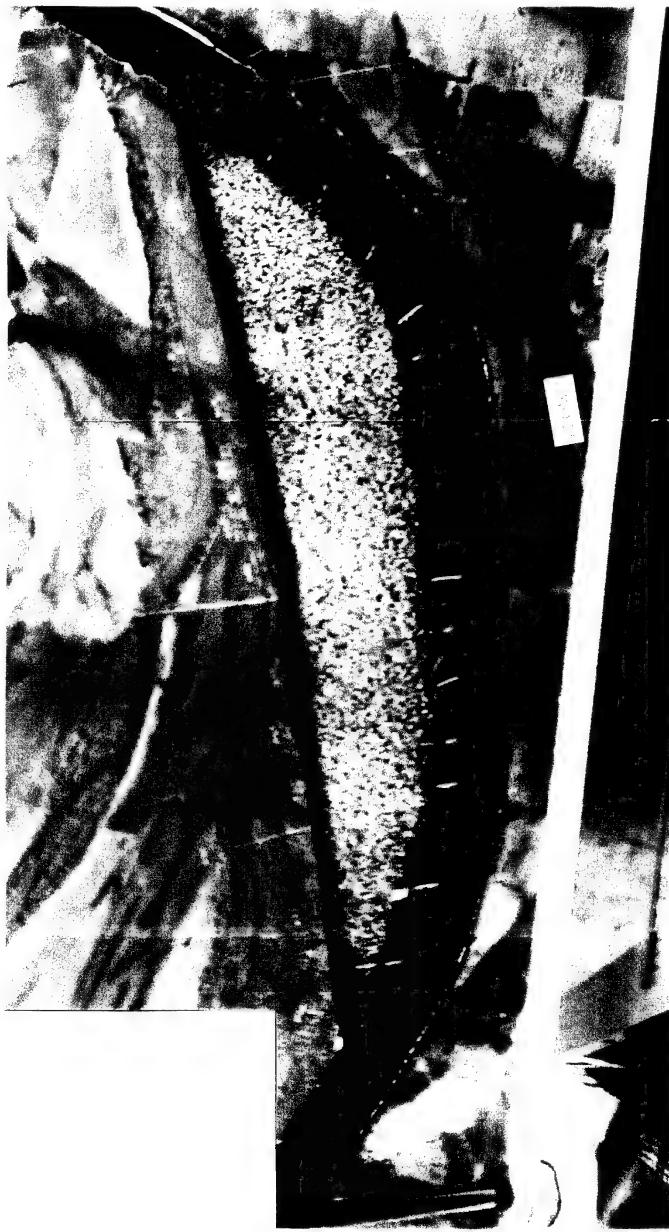
U.S. ARMY ENGINEER DIVISION NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA	
SEDIMENTATION STUDY - MICRO MODEL MISSOURI RIVER COPELAND BEND RIVER MILES 569 TO 564½	
ALTERNATIVE: 5	
1200 1000 800 600 400 200 0 300	1200 1000 800 600 400 200 0 300
SECTION LINE: COPELAND BEND	SECTION LINE: COPELAND BEND
PLOT SCALE: 1:200	PLOT SCALE: 1:200
DATE: 1-25-99	DATE: 1-25-99
PLATE NO. 29	PLATE NO. 29

IOWA
FREMONT COUNTY

NEBRASKA OGE COUNTY

BLUE LINE • EQUILIBRIUM
LINE, MICRO MODEL

EXISTING BANKLINE, MISSOURI RIVER



	U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA	
Sedimentation Study, Missouri River Copeland Bend, Flow Visualization		SCALE 50' Landward Notch at 5 CRP Alternative 5
PREPARED BY: R. Dray CHECKED BY: D. Sorenson	DATE: FEBRUARY, 1989	FILE NO. 31

ELEVATIONS REFERENCED

TO CRP

EL. 5
EL. 10
EL. 15
EL. 20
EL. 30

IOWA

FREMONT COUNTY

EXISTING BANKLINE, MISSOURI RIVER

BLUE LINE = EQUILIBRIUM
LINE, MICRO MODEL

NEBRASKA
OTOE COUNTY

50' LANDWARD NOTCH @ -5 CRP
WITH 16 - NEW CHEVRONS @ +2 CRP

U.S. ARMY ENGINEER DIVISION NORTHWESTERN
CORPS OF ENGINEERS
OMAHA, NEBRASKA
SEDIMENTATION STUDY - MICRO MODEL STUDY
MISSOURI RIVER COPELAND BEND
ENVEP MILES 569 TO 564.5
ALTERNATIVE 6

1000
1000 1000 1000 1000 1000 1000
0 200 400 600 800 1000 1200 1400
PL 07 SCALE: 1:1000 DATE: 3/2
PLOT DATE: X



	U. S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA
PREPARED BY: R. Devaney CHECKED BY: D. Szedlar	Sedimentation Study, Missouri River Copeland Bend, Flow Visualization Alternative 6 Landward Notch, .5 CRP, Chevrons at .2 CRP
DATE: FEBRUARY 1988	PLATE NO. 34

ELEVATIONS REFERENCED

TO CRP

ELL. 5
ELL. 0
ELL. -5
ELL. -10
ELL. -15
ELL. -20
ELL. -25
ELL. -30

IOWA

FREMONT COUNTY

BLUE LINE = EQUILIBRUM
LINE, MICRO MODEL

EXISTING BANKLINE, MISSOURI RIVER

-6 - NEW BENDWAY WEIRS

NEBRASKA
OTOE COUNTY

DEGRADE DIKES TO -2 CRP
WITH 16 - NEW CHEVRONS @ -2 CRP
AND 6 - NEW BENDWAY WEIRS @ -15 CRP

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS
OMAHA, NEBRASKA

SEDIMENTATION STUDY - MICRO MODEL STUDY
MISSOURI RIVER, COPELAND BEND
RIVER MILES 569 TO 56.5

ALTERNATIVE 2

1200 1000 800 600 400 200 0 1200

PLAT NO. 35

PLAT DATE: X

PLOT DATE: X

PLOT NO. 1200

DESIGN FILE, CORRIDOR

PLAT NO.

IOWA
FREMONT COUNTY

BLUE LINE • EQUILIBRIUM
LINE, MICRO MODEL

EXISTING BANKLINE, MISSOURI RIVER

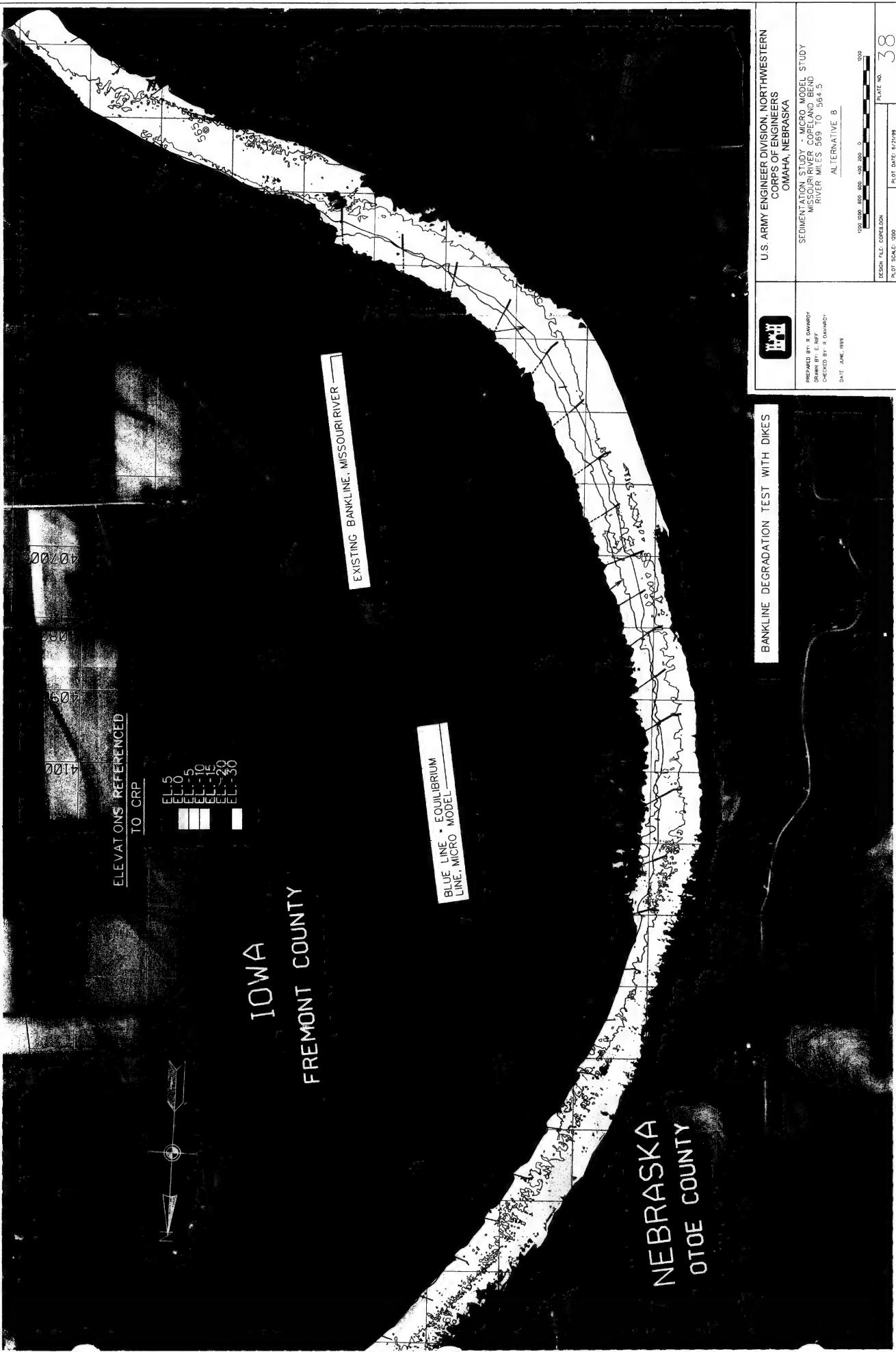
NEBRASKA
OTOE COUNTY

	U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA
PREPARED BY: R. DAWRDY DRAWN BY: E. REFF CHECKED BY: R. DAWRDY DATE: JUNE, 1999	SEDIMENTATION STUDY - MICRO MODEL STUDY MISSOURI RIVER, CO-PLAN BEND RIVER MILES 569 TO 564.5 ALTERNATIVE 7 DIFFERENCE MAP
DESIGN FILE: 047-1004 PLOT SCALE: 1:2000 PLOT DATE: 6/21/99	PLATE NO. 36 1000 800 600 400 200 0 1000





	U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA
PREPARED BY: A. Hawley CHECKED BY: D. Gaddis DATE: 1 FEBRUARY 1993	Sedimentation Study Missouri River Copeland Bend, Flow Visualization Alternative 7 Benday Weirs, -15 C.R.P., With Alternative 2
	PAGE NO. 37



IOWA
FREMONT COUNTY

BLUE LINE - EQUILIBRIUM
LINE, MICRO MODEL

EXISTING BANKLINE, MISSOURI RIVER

NEBRASKA
OTOE COUNTY

	U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA
PREPARED BY: R. DAWSON DRAWN BY: L. H. HARRIS CHECKED BY: M. COXWELL DATE: JUNE 1999	SEDIMENTATION STUDY - MICRO MODEL STUDY MISSOURI RIVER COPELAND BEND RIVER MILES 569 TO 564.5 ALTERNATIVE B DIFFERENCE MAP
DESIGN FILE OF RECORD PLOT SCALE: 1:2000	1200 1000 800 600 400 200 0 PLATE NO. 39 PLOT DATE: 6/21/99





	U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA
PREPARED BY: R. O'neill CHECKED BY: C. Geller 3/2000	Sedimentation Study, Missouri River Copeland Bend. Flow Visualization Alternative 8 Bankline Degradation Test with Dikes in Place
U.S. ARMY CORPS OF ENGINEERS	PLATE NO. 40

ELEVATIONS REFERENCED
TO CRP



EL. 5
EL. 0
EL. -5
EL. -10
EL. -15
EL. -20
EL. -30

IOWA

FREMONT COUNTY

BLUE LINE • EQUILIBRIUM
LINE, MICRO MODEL

EXISTING BANKLINE, MISSOURI RIVER

NEBRASKA
OTOE COUNTY

DIKES REMOVED @ BANKLINE NEAR EQUILIBRIUM

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA	
SEDIMENTATION STUDY - MICRO MODEL STUDY MISSOURI RIVER, COPIA LAND BEND RIVER MILES 565.0 TO 564.5	
ALTERNATIVE 9	
1000 800 600 400 200 0 1000	
DESIGN ELE. CORP. 200	PLOT DATE X
PLOT SCALE 1:200	PLATE NO. 41

IOWA
FREMONT COUNTY

BLUE LINE - EQUILIBRIUM
LINE, MICRO MODEL

EXISTING BANKLINE, MISSOURI RIVER

NEBRASKA
OTOE COUNTY

	U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA
INSTRUCTED BY: R. DAWSON DEMANDED: C. STAFF CHECKED BY: R. BARNES	SEDIMENTATION STUDY - MICRO MODEL STUDY MISSOURI RIVER COPELAND BEND RIVER MILES 369 TO 364 5 ALTERNATIVE 3 DIFFERENCE MAP
DATE: JUNE, 1999	SCALE: 1:24,000 1000 900 800 700 600 500 400 300 200 0 1000
DESIGN FILE: 0910.DGN	PLATE NO. 42
PLAT SCALE: 1:200	PLAT DATE: 6/21/99



ELEVATIONS REFERENCED

TO CRP

EL-5
EL-0
EL-5
EL-10
EL-15
EL-20
EL-25
EL-30

IOWA

FREMONT COUNTY

NEBRASKA

EXISTING BANKLINE, MISSOURI RIVER

BLUE LINE - EQUILIBRIUM
LINE, MICRO MODEL

NEBRASKA
OTOE COUNTY

BANKLINE DEGRADATION TEST
WITH DIKES REMOVED

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS
OMAHA, NEBRASKA

SEDIMENTATION STUDY - MICRO MODEL STUDY
MISSOURI RIVER COPELAND BEND
RIVER MILES 363 TO 564.5
ALTERNATIVE 10

DESIGN FILE: COPELAND.DGN
SHEET SCALE: 1:2000
PLATE NO. 43
PLAT DATE: X

1200 1000 800 600 400 200 0

1200 1000 800 600 400 200 0

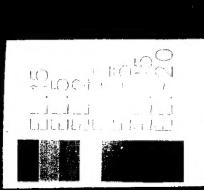
1200 1000 800 600 400 200 0

IOWA
FREMONT COUNTY

BLUE LINE = EQUILIBRIUM
LINE, MICRO MODEL

EXISTING BANKLINE, MISSOURI RIVER

NEBRASKA
COUNTY
OTOE



	U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA	SEDIMENTATION STUDY - MICRO MODEL STUDY MISSOURI RIVER COPEL AND BEND RIVER MILES 569 TO 545 ALTERNATIVE TO DIFFERENCE MAP	PLATE NO. 44
PREPARED BY: R. DAWNEY DRAWN BY: R. DAWNEY CHECKED BY: R. DAWNEY DATE: JUNE, 1999	1000 900 800 700 600 500 400 300 200 100	1000 900 800 700 600 500 400 300 200	PLATE NO. 44



U.S. ARMY ENGINEER DIVISION, NORTHWESTERN CORPS OF ENGINEERS OMAHA, NEBRASKA	Sedimentation Study, Missouri River Copeland Bend, Flow Visualization	
RECORDED BY: R. Darrow CHECKED BY: D. Grotten	0	1000
DATE: FEBRUARY 1999	Alternative 10	Maximum Contraction Test With Dike Removal
PLATE NO.	45	